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## SYSTEMS AND METHODS FOR A NAVIGATIONAL DEVICE WITH IMPROVED ROUTE CALCULATION CAPABILITIES

### Related Application

5        This application is a divisional of U.S. Application Serial No. 10/028,057  
filed December 20, 2001, which application is incorporated herein by reference.

### Field of the Invention

10       The present invention relates generally to navigational devices, and in  
particular to navigational devices with improved route calculation capabilities.

### Background of the Invention

15       Route planning devices are well known in the field of navigational  
instruments. The method of route planning implemented by known prior art systems  
depends on the capabilities of system resources, such as processor speed and the  
amount and speed of memory. As increased system capability also increases system  
cost, the method of route planning implemented by a navigation device is a function  
of overall system cost.

20       One feature of increased system capability involves off-route recalculation  
capabilities. Many conventional navigational devices simply do not incorporate an  
off-route recalculation functionality in order to reduce system complexity and  
maintain a low overall system cost. Some of these devices may alert the user that  
they are off course, but they do not perform any course recalculation. In these  
25       devices, the user must halt their journey or attempt to relocate themselves on the  
prior planned route via traditional navigation methods, e.g. asking directions or  
using a conventional map. With some devices, the user may still be able to see the  
previously planned route, but the user will have to employ his or her own decision  
making to chart back onto the displayed route. This can be time consuming and

provide frustration to a user who is likely unfamiliar with the routes surrounding their errant location.

5 Additionally, in order to calculate a route it is necessary to select a starting position to begin the route calculation. The route calculation algorithm invariably takes a small but finite amount of time, maybe on the order of 10 to 20 seconds. If the current position of the device is used as the starting position for the route calculation, a new route is generated based on the position that was known historically. Thus, a moving device will have traveled some distance beyond that historical position. In other words, the new route will have a starting point which  
10 corresponds to the historical position which may or may not correspond to the device's current position. Thus, if a turn or other maneuver is indicated as a function of getting from the historical position (as known at the time the calculation was started) to a given destination, the device will easily be beyond the turn that was generated by the route calculation algorithm.

15 While stopping travel during the route calculation process may solve the stated problem of generating a route while in motion, in many cases halting travel is not a viable alternative. For example, when the user is traveling on an interstate it is entirely impossible to simply stop. The alternative of pulling off on the shoulder of a road is undesirable and can be dangerous. Pulling off on an exit is equally  
20 undesirable since doing so increases travel time and provides an added inconvenience to the user. In other instances, such as navigating downtown city streets, the traffic issues alone may prevent the user from stopping his or her vehicle during the recalculation process. Even if the user has the ability to safely stop his or her vehicle, such as when traveling in a neighborhood, the inconvenience factor is  
25 present.

In summary, current prior art systems have created a spectrum of products in which the degree of navigational accuracy is dictated primarily by the cost of the system. The lower cost systems currently offer a low degree of accuracy that is

often inadequate for users. Therefore, there exists a need for a navigational route planning device which is more efficient and accurate than current low cost systems, without requiring more expensive system resources. In addition, there is also a need for a navigational route planning device which provides a user with more  
5 understandable, accurate and timely route calculation capabilities.

### Summary of the Invention

The above mentioned problems of navigational devices are addressed by the present invention and will be understood by reading and studying the following  
10 specification. Systems and methods are provided for a navigational route planning device which is more efficient and accurate than current low cost systems, without requiring the more expensive system resources. The systems and methods of the present invention offer an improved navigational route planning device which provides a user with more understandable, accurate and timely route calculation  
15 capabilities.

In one embodiment of the present invention, an electronic navigational aid device with improved route calculation capabilities is provided. The navigational aid device includes a processor with a display connected to the processor. A memory is connected to the processor as well. The memory includes cartographic  
20 data and a route to a desired destination stored therein. The cartographic data includes data indicative of thoroughfares of a plurality of types. The device processes travel along the route. The device is capable of selecting an appropriate starting point for a route calculation and capable of recognizing when the device has deviated from a route. When the device is off-route, the device calculates a new  
25 route to navigate to the desired destination. In order to select an appropriate starting point for the route calculation or recalculation, the device adjusts a starting point for the new route to a location forward along a current thoroughfare on which the device is located or traveling such that the device is on the route at a time when the

new route calculation is completed.

These and other embodiments, aspects, advantages, and features of the present invention will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art by reference to the following description of the invention and referenced drawings or by practice of the invention. The aspects, advantages, and features of the invention are realized and attained by means of the instrumentalities, procedures, and combinations particularly pointed out in the appended claims.

10

#### Brief Description of the Drawings

Figure 1 is a representative view of a Global Positioning System (GPS);

Figures 2A and 2B illustrate views for one embodiment of an electronic navigational device according to the teachings of the present invention;

Figures 3A-3C illustrate views for another embodiment of an electronic navigational device according to the teachings of the present invention;

Figure 4A is a block diagram of one embodiment for the electronic components within the hardware of Figures 2A-2B according to the teachings of the present invention;

Figure 4B is a block diagram of one embodiment for the electronic components within the hardware of Figures 3A-3C according to the teachings of the present invention;

Figure 5 is a block diagram of a navigation system according to the teachings of the present invention;

Figure 6 is a flow diagram of one embodiment of a navigation aid method according to the teachings of the present invention; and

Figure 7 is a flow diagram of another embodiment of a navigation aid method according to the teachings of the present invention.

#### Detailed Description of the Invention

5        In the following detailed description of the invention, reference is made to the accompanying drawings which form a part hereof, and in which is shown, by way of illustration, specific embodiments in which the invention may be practiced. The embodiments are intended to describe aspects of the invention in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments  
10       may be utilized and changes may be made without departing from the scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is defined only by the appended claims, along with the full scope of equivalents to which such claims are entitled.

15       The present invention is drawn to navigational systems and devices having route calculation capabilities. One type of navigational system includes Global Positioning Systems (GPS). Such systems are known and have a variety of uses. In general, GPS is a satellite-based radio navigation system capable of determining continuous position, velocity, time, and in some instances direction information for  
20       an unlimited number of users. Formally known as NAVSTAR, the GPS incorporates a plurality of satellites which orbit the earth in extremely precise orbits. Based on these precise orbits, GPS satellites can relay their location to any number of receiving units.

      The GPS system is implemented when a device specially equipped to  
25       receive GPS data begins scanning radio frequencies for GPS satellite signals. Upon receiving a radio signal from a GPS satellite, the device can determine the precise location of that satellite via one of different conventional methods. The device will continue scanning for signals until it has acquired at least three different satellite

signals. Implementing geometric triangulation, the receiver utilizes the three known positions to determine its own two-dimensional position relative to the satellites. Additionally, acquiring a fourth satellite signal will allow the receiving device to calculate its three-dimensional position by the same geometrical calculation. The positioning and velocity data can be updated in real time on a continuous basis by an unlimited number of users.

Figure 1 is representative of a GPS denoted generally by reference numeral 100. A plurality of satellites 120 are in orbit about the Earth 124. The orbit of each satellite 120 is not necessarily synchronous with the orbits of other satellites 120 and, in fact, is likely asynchronous. A GPS receiver device 140 of the present invention is shown receiving spread spectrum GPS satellite signals 160 from the various satellites 120.

The spread spectrum signals 160 continuously transmitted from each satellite 120 utilize a highly accurate frequency standard accomplished with an extremely accurate atomic clock. Each satellite 120, as part of its data signal transmission 160, transmits a data stream indicative of that particular satellite 120. It will be appreciated by those skilled in the relevant art that the GPS receiver device 140 must acquire spread spectrum GPS satellite signals 160 from at least three satellites 120 for the GPS receiver device 140 to calculate its two-dimensional position by triangulation. Acquisition of an additional signal 160, resulting in signals 160 from a total of four satellites 120, permits GPS receiver device 140 to calculate its three-dimensional position.

Figures 2A and 2B illustrate views for one embodiment of an electronic navigational device 230 according to the teachings of the present invention. As one of ordinary skill in the art will understand upon reading this disclosure, the device can be portable and can be utilized in any number of implementations such as automobile, personal marine craft, and avionic navigation. In the embodiment of Figure 2A a front view of the navigational device 230 is provided showing the

5 navigational device has a generally rectangular housing 232. The housing 232 is constructed of resilient material and has been rounded for aesthetic and ergonomic purposes. As shown in Figure 2A, the control face 234 has access slots for an input key pad 238, other individual keys 239, and a display screen 236. In one embodiment, the display screen 236 is a LCD display which is capable of displaying both text and graphical information. The invention, however, is not so limited. Audio information can likewise be provided in one embodiment.

10 In Figure 2B, a side view of the navigational device 230 is provided. Figure 2B illustrates that the device's housing 232 is defined by an outer front case 240 and a rear case 242. As shown in Figure 2B, the outer front case 240 is defined by the control face 234. In the embodiment shown in Figure 2B, the outer front case 240 and the rear case 242 are made of one molded piece to form the device housing 232 and support input key pad 238, other individual keys 239, and display screen 236 in respective access slots shown in the control face 234 of Figure 2A.

15 Figures 3A-3C illustrate views for another embodiment of an electronic navigational device 310 according to the teachings of the present invention. The navigational device 310 shown in Figures 3A-3C includes a personal digital assistant (PDA) with integrated GPS receiver and cellular transceiver according to the teachings of the present invention. The GPS integrated PDA operates with an operating system (OS) such as, for example, the well-known Palm or Pocket PC operating systems, or the lesser-used Linux OS. As shown in the top view of Figure 3A, the GPS integrated PDA 310 includes an internal integrated GPS patch antenna 314 and a cellular transceiver 316 contained in a housing 318. The housing 318 is generally rectangular with a low profile and has a front face 320 extending from a top end 322 to a bottom end 324. Mounted on front face 320 is a display screen 326, which is touch sensitive and responsive to a stylus 330 (shown stored in the side view of Figure 3B) or a finger touch. Figures 3A-3C illustrate the stylus 330 nested within housing 318 for storage and convenient access in a conventional



manner. The embodiment shown in Figure 3A illustrates a number of control buttons, or input keys 328 positioned toward the bottom end 324. The invention, however, is not so limited and one of ordinary skill in the art will appreciate that the input keys 328 can be positioned toward the top end 322 or at any other suitable location. The end view of Figure 3C illustrates a map data cartridge bay slot 332 and headphone jack 334 provided at the top end 322 of the housing 318. Again, the invention is not so limited and one of ordinary skill in the art will appreciate that a map data cartridge bay slot 332 and headphone jack 334 can be provided at the bottom end 324, separately at opposite ends, or at any other suitable location.

10 It should be understood that the structure of GPS integrated PDA 310 is shown as illustrative of one type of integrated PDA navigation device. Other physical structures, such as a cellular telephone and a vehicle-mounted unit are contemplated within the scope of this invention.

15 Figures 2A-2B and 3A-3C are provided as illustrative examples of hardware components for a navigational device according to the teachings of the present invention. However, the invention is not limited to the configuration shown in Figures 2A-2B and 3A-3C. One of ordinary skill in the art will appreciate other suitable designs for a hardware device which can accommodate the present invention.

20 Figure 4A is a block diagram of one embodiment for the electronic components within the hardware of Figures 2A-2B, such as within housing 232 and utilized by the electronic navigational device. In the embodiment shown in Figure 4A, the electronic components include a processor 410 which is connected to an input 420, such as keypad via line 425. It will be understood that input 420 may  
25 alternatively be a microphone for receiving voice commands. Processor 410 communicates with memory 430 via line 435. Processor 410 also communicates with display screen 440 via line 445. An antenna/receiver 450, such as a GPS antenna/receiver is connected to processor 410 via line 455. It will be understood

that the antenna and receiver, designated by reference numeral 450, are combined schematically for illustration, but that the antenna and receiver may be separately located components, and that the antenna may be a GPS patch antenna or a helical antenna. The electronic components further include I/O ports 470 connected to  
5 processor 410 via line 475.

Figure 4B is a block diagram of one embodiment for the electronic components within the hardware of Figures 3A-3C and utilized by the GPS integrated PDA 310 according to the teachings of the present invention. The electronic components shown in Figure 4B include a processor 436 which is  
10 connected to the GPS antenna 414 through GPS receiver 438 via line 441. The processor 436 interacts with an operating system (such as PalmOS; Pocket PC) that runs selected software depending on the intended use of the PDA 310. Processor 436 is coupled with memory 442 such as RAM via line 444, and power source 446 for powering the electronic components of PDA 310. The processor 436  
15 communicates with touch sensitive display screen 426 via data line 448.

The electronic components further include two other input sources that are connected to the processor 436. Control buttons 428 are connected to processor 436 via line 451 and a map data cartridge 433 inserted into cartridge bay 432 is connected via line 452. A conventional serial I/O port 454 is connected to the  
20 processor 436 via line 456. Cellular antenna 416 is connected to cellular transceiver 458, which is connected to the processor 436 via line 466. Processor 436 is connected to the speaker/headphone jack 434 via line 462. The PDA 310 may also include an infrared port (not shown) coupled to the processor 436 that may be used to beam information from one PDA to another.

25 As will be understood by one of ordinary skill in the art, the electronic components shown in Figures 4A and 4B are powered by a power source in a conventional manner. As will be understood by one of ordinary skill in the art, different configurations of the components shown in Figures 4A and 4B are

considered within the scope of the present invention. For example, in one embodiment, the components shown in Figures 4A and 4B are in communication with one another via wireless connections and the like. Thus, the scope of the navigation device of the present invention includes a portable electronic  
5 navigational aid device.

Using the processing algorithms of the present invention, the device selects an appropriate starting point for performing a new route calculation and the device recognizes when the device has deviated from the route stored in memory. The device then uses those electronic components to calculate a new route to navigate to  
10 the desired destination. According to the teachings of the present invention, the device adjusts a starting point for the new route calculation to a location forward along a current thoroughfare on which the device is located or traveling such that the location is at or forward of the device at a time when the new route calculation is completed. In other words, the device adjusts a starting point for the new route  
15 calculation to a location forward along a current thoroughfare on which the device is located or traveling such that the device is on the route at a time when the new route calculation is completed. According to the teachings of the present invention, the device incorporates these and other functions as will be explained in more detail below in connection with Figures 6 and 7.

20 Figure 5 is a block diagram of an embodiment of a navigation system which can be adapted to the teachings of the present invention. The navigation system includes a server 502. According to one embodiment, the server 502 includes a processor 504 operably coupled to memory 506, and further includes a transmitter 508 and a receiver 510 to send and receive data, communication, and/or other  
25 propagated signals. The transmitter 508 and receiver 510 are selected or designed according to the communication requirements and the communication technology used in the communication design for the navigation system. The functions of the transmitter 508 and the receiver 510 may be combined into a single transceiver.

The navigation system further includes a mass data storage 512 coupled to the server 502 via communication link 514. The mass data storage 512 contains a store of navigation data. One of ordinary skill in the art will understand, upon reading and comprehending this disclosure, that the mass data storage 512 can be  
5 separate device from the server 502 or can be incorporated into the server 502.

In one embodiment of the present invention, the navigation system further includes a navigation device 516 adapted to communicate with the server 502 through the communication channel 518. According to one embodiment, the navigation device 516 includes a processor and memory, as previously shown and  
10 described with respect to the block diagram of Figures 4A and 4B. Furthermore, the navigation device 516 includes a transmitter 520 and receiver 522 to send and receive communication signals through the communication channel 518. The transmitter 520 and receiver 522 are selected or designed according to the communication requirements and the communication technology used in the  
15 communication design for the navigation system. The functions of the transmitter 520 and receiver 522 may be combined into a single transceiver.

Software stored in the server memory 506 provides instructions for the processor 504 and allows the server 502 to provide services to the navigation device 516. One service provided by the server 502 involves processing requests from the navigation device 516 and transmitting navigation data from the mass data storage  
20 512 to the navigation device 516. According to one embodiment, another service provided by the server 502 includes processing the navigation data using various algorithms for a desired application, and sending the results of these calculations to the navigation device 516.

25 The communication channel 518 is the propagating medium or path that connects the navigation device 516 and the server 502. According to one embodiment, both the server 502 and the navigation device 516 include a transmitter for transmitting data through the communication channel and a receiver

for receiving data that has been transmitted through the communication channel.

The communication channel 518 is not limited to a particular communication technology. Additionally, the communication channel 518 is not limited to a single communication technology; that is, the channel 518 may include  
5 several communication links that use a variety of technology. For example, according to various embodiments, the communication channel is adapted to provide a path for electrical, optical, and/or electromagnetic communications. As such, the communication channel includes, but is not limited to, one or a combination of the following: electrical circuits, electrical conductors such as wires  
10 and coaxial cables, fiber optic cables, converters, radio-frequency (RF) waveguides, the atmosphere, and empty space. Furthermore, according to various embodiments, the communication channel includes intermediate devices such as routers, repeaters, buffers, transmitters, and receivers, for example.

In one embodiment, for example, the communication channel 518 includes  
15 telephone and computer networks. Furthermore, in various embodiments, the communication channel 516 is capable of accommodating wireless communication such as radio frequency, microwave frequency and infrared communication, and the like. Additionally, according to various embodiments, the communication channel 516 accommodates satellite communication.

20 The communication signals transmitted through the communication channel 518 include such signals as may be required or desired for a given communication technology. For example, the signals may be adapted to be used in cellular communication technology, such as time division multiple access (TDMA), frequency division multiple access (FDMA), code division multiple access  
25 (CDMA), global system for mobile communications (GSM), and the like. Both digital and analog signals may be transmitted through the communication channel 518. According to various embodiments, these signals are modulated, encrypted and/or compressed signals as may be desirable for the communication technology.

The mass data storage includes sufficient memory for the desired navigation application. Examples of mass data storage include magnetic data storage media such as hard drives, optical data storage media such as CD ROMs, charge storing data storage media such as Flash memory, and molecular memory, such as now  
5 known or hereinafter developed.

According to one embodiment of the navigation system, the 502 server includes a remote server accessed by the navigation device 516 through a wireless channel. According to other embodiments of the navigation system, the server 502 includes a network server located on a local area network (LAN), wide area network  
10 (WAN), a virtual private network (VPN) and server farms.

According to another embodiment of the navigation system, the server 502 includes a personal computer such as a desktop or laptop computer. In one embodiment, the communication channel 518 is a cable connected between the personal computer and the navigation device. According to one embodiment, the  
15 communication channel 518 is a wireless connection between the personal computer and the navigation device 516.

Figure 5 presents yet another embodiment for a collective set of electronic components adapted to the present invention. As one of ordinary skill in the art will understand upon reading and comprehending this disclosure, the navigation system  
20 of Figure 5 is adapted to the present invention in a manner distinguishable from that described and explained in detail in connection with Figures 4A and 4B.

That is, the navigational system 500 of Figure 5 is likewise adapted to provide an electronic navigational aid device 516 with route calculation capabilities. In this embodiment, the processor 504 in the server 502 is used to handle the bulk of  
25 the system's processing needs. The mass storage device 512 connected to the server can include volumes more cartographic and route data than that which is able to be maintained on the navigational device 516 itself. In this embodiment, the server 502 processes the majority of a device's travel along the route using a set of

processing algorithms and the cartographic and route data stored in memory 512 and can operate on signals, e.g. GPS signals, originally received by the navigational device 516. Similar to the navigational device of Figures 4A and 4B, the navigation device 516 in system 500 is outfitted with a display 524 and GPS capabilities 526.

5       As described and explained in detail in connection with Figures 4A and 4B, the navigation system of Figure 5 uses processing algorithms select an appropriate starting point for performing a new route calculation. And, the system uses the processing algorithms to recognize when the device has deviated from the route and to perform a new route calculation. The system then uses the electronic components  
10 shown in Figure 5 to select the appropriate starting point and calculate a new route for navigating the device 516 to the desired destination. As one of ordinary skill in the art will understand upon reading and comprehending this disclosure, a user of the navigation device 516 can be proximate to or accompanying the navigation device 516. The invention however, is not so limited.

15       According to the teachings of the present invention, the system adjusts a starting point for the new route calculation to a location forward along a current thoroughfare on which the device is located or traveling such that the location is at or forward of the device at a time when the new route calculation is completed. In other words, the device adjusts a starting point for the new route calculation to a  
20 location forward along a current thoroughfare on which the device is located or traveling such that the device is on the route at a time when the new route calculation is completed. The navigation device 516 of the present invention includes a portable electronic navigational aid device. In one embodiment, the portable electronic navigational aid device includes a personal digital assistant  
25 (PDA). In one embodiment, the portable electronic navigational aid device includes a wireless communications device.

The features and functionality explained and described in detail above in connection with the device of Figures 4A and 4B are likewise available in the

system 500 of Figure 5. That is, in one embodiment the navigation device 516 further provides audio and visual cues to aid the navigation along the route.

Figure 6 is a flow diagram of one embodiment of a navigation aid method according to the teachings of the present invention. The navigation aid method includes a method for performing a route calculation within a navigation device or navigation system as described and explained in detail above in connection with Figures 4A, 4B, and 5. And, as described above, a processor is used for processing signals which include input data from input devices, e.g. keypads, other input keys, or other inputs, GPS signals from GPS components, and data received from I/O ports in order to perform the methods described herein. In the embodiment shown in Figure 6, the navigation aid method for performing a route calculation includes detecting when a navigation device has deviated from a first route of navigation and calculating the device's current location in block 610. The device's travel speed is calculated in block 620. A calculation time is determined for processing a second route of navigation from the device's current location to a desired destination in block 630. In one embodiment, the calculation time for processing a second route of navigation is estimated based on a distance from the device's current location to the desired destination. In one embodiment, the calculation time is estimated based on a complexity of the thoroughfares from the device's current location to the desired destination. In one embodiment, the calculation time for processing the second, or new route of navigation is determined as a time equal to or greater than an actual previous calculation time. Subsequently, in block 640, a starting point for the second route of navigation is selected based on the device's travel speed and the determined calculation time for processing the second, or new route. Once the second, or new route has been determined in block 645, the method proceeds to block 650 and navigates the route. As one of ordinary skill in the art will understand upon reading and comprehending this disclosure, the method embodiment described in Figure 6 is repeatable, returning to block 610 in order to



continually assess whether a then current position of the navigation device has deviated from the route.

In one embodiment of the present invention, detecting when the device has deviated from the first route of navigation and calculating the device's current  
5 location includes using a global positioning system. According to the teachings of the present invention, selecting a starting point for the second route of navigation includes selecting a starting point forward on a current thoroughfare on which the device is located or traveling such that the device is on the route at a time when the new route calculation is completed. In one embodiment, selecting a starting point  
10 for the second route can include a starting point located at an end of a current thoroughfare on which the device is traveling.

In one method embodiment of the present invention, the device operates on data indicative of a set of travel habits of the device on each of the plurality of types of thoroughfares and stores the travel habit data in the memory. In one embodiment  
15 of the present invention, the travel habit data includes data relating to the thoroughfare classification, the speed classification of the thoroughfare, the time of day, and the historical travel speed of the device on the particular thoroughfare. In the invention, the device regularly calculates the device's current position. The display continuously displays the device's position and uses audio and/or visual  
20 instructions to navigate to the starting point of the new route calculation as well as to navigate along the new route.

According to the teachings of the present invention, and as used herein, the device travel speed includes an estimated device travel speed, a learned device travel speed, and a current device travel speed. As used herein, a learned device  
25 travel speed includes travel speed data that is obtained from the data indicative of a set of travel habits of the device on each of the plurality of types of thoroughfares. As used herein, an estimated travel speed includes travel speed data that is obtained from data indicative of a thoroughfare's classification type such as an interstate, city

street, residential road and the like, and includes travel speed data that is obtained from the data indicative of a thoroughfare's speed classification such as a 25 mph, 55 mph, 75 mph or other roadway speed class on each of the plurality of types of thoroughfares. In one embodiment according to the teachings of the present invention, calculating the device's travel speed includes using a device travel speed which is the greater of the device's current travel speed and the device's learned travel speed or estimated travel speed.

In one method embodiment, in order to perform the new route calculation, the device calculates a length of a thoroughfare on which the device is currently traveling and calculates the device's travel speed to calculate how far the device will travel on the current thoroughfare before a route calculation can be completed in order to adjust the starting point.

According to the teachings of the present invention, the device of the present invention includes a portable electronic navigational aid device. In one embodiment, the portable electronic navigation aid device includes a portable vehicle, or automobile navigation device. In one embodiment, the portable electronic navigational aid device includes a personal digital assistant (PDA). In one embodiment, the portable electronic navigational aid device includes a wireless communications device.

Another method embodiment of the present invention includes an electronic navigational aid device with route calculation capabilities. As described above the electronic components include a processor and a memory connected to the processor. In this embodiment, the memory has resident cartographic data and a route stored therein to navigate the device from a beginning position to a desired destination. As before, the cartographic data including data indicative of thoroughfares of a plurality of types. A display is connected to the processor and capable of displaying the cartographic data, the route to the desired destination, and the device's position. The device processes travel along the route and provides the

device's location data to the display. In one embodiment, the device further provides audio and visual cues to aid navigation along the route.

5 In the invention, the method includes recognizing when the device has deviated from the route and calculating a new route to navigate the device to the desired destination. The method includes adjusting a starting point for the new route calculation to a location forward along a current thoroughfare on which the device is traveling. In calculating the new route the device calculates the device's travel speed to calculate how far the device will travel on the current thoroughfare before a the new route calculation can be completed. In one embodiment, in  
10 calculating the new route the device calculates a distance from the device's current position to the desired destination to estimate a first route calculation time. The device then uses a travel speed and the first route calculation time to set the starting point for the new route calculation.

15 According to the teachings of the present invention, if the device is not determined to be on the new route after an actual first route calculation time then the device uses a second route calculation time and the device's travel velocity to set a new starting point, on the current thoroughfare on which the device is traveling, for another new route calculation. In one embodiment, the second route calculation time is equal to or greater than an actual first route calculation time.

20 In one embodiment of the present invention, the starting point is set at the end of the current thoroughfare on which the device is traveling. However, as will be understood by one of ordinary skill in the art upon reading this disclosure, there will be instances for which setting the starting point at the end of the current thoroughfare will not adequately set the starting point at a location forward of the  
25 device based on the device's travel speed and the necessary route calculation time. In those instances, the device of the present invention uses a set of criteria to analyze adjacency information and determine a straightest path in order to adjust the starting point for the new route calculation to, or sufficiently forward of, a location

at which the device is likely to be at the end of the route calculation time, such that the device is on the route at a time when the new route calculation is completed. As used herein, the term adjacency information, or adjacencies, is intended to include any thoroughfare which intersects the current thoroughfare on which the device is traveling. Every place two thoroughfares intersect is termed a node. Thus, every node on a given thoroughfare connects that thoroughfare to an adjacency, or adjacent thoroughfare.

Figure 7 is a flow diagram of another embodiment of a navigation aid method according to the teachings of the present invention. The navigation aid method includes a method for performing a route calculation within a navigation device or navigation system such as described and explained in detail above in connection with Figures 4A, 4B, and 5. And, as described above, a processor is used for processing signals which include input data from user input devices, e.g. keypads or other inputs, GPS signals from GPS device/system components, and data received from I/O ports in order to perform the methods described herein.

As shown in Figure 7, the navigation aid method for performing a route calculation includes determining whether the navigation device is moving and cartographically- or map-matched to one of a plurality of thoroughfares in block 710. In one embodiment as used herein, cartographically- or map-matched is intended to imply determining whether the device is located on a thoroughfare. In one embodiment, determining whether the navigation device is moving and cartographically- or map-matched to one of a plurality of thoroughfares includes using a GPS. According to the method, if the device is not cartographically- or map-matched to a thoroughfare then the method determines the thoroughfare on which the device is most likely to be located. As one of ordinary skill in the art will understand upon reading this disclosure, the method includes retrieving a current position of the navigation device, cartographic data for a plurality of thoroughfares in a network, and data for a desired destination.

If the device is not moving, then once the current position of the navigation device is determined the method proceeds to block 750 and proceeds to calculate a route using a current position of the navigational device as a starting point for the route calculation.

5        On the other hand, if the navigation device is moving, the method proceeds to block 720 where the method determines a travel speed or velocity of the navigation device and determines a route calculation time for providing a route from the current geographic position of the navigation device to a desired destination. In one embodiment, the method estimates a route calculation time for providing a route  
10    from the current geographic position of the navigation device to a desired destination. The method in block 720 for determining a travel speed or velocity of the navigation device and determining a route calculation time includes that which has been described above in connection with Figure 6. The method in block 720 includes using this information to calculate a distance predicting how far the  
15    navigation device will travel, along a thoroughfare on which the navigation device is moving, within the determined route calculation time such that the device is on the route at a time when the new route calculation is completed.

In block 730, the method adjusts a starting point for the new route calculation to a location forward along a current thoroughfare on which the device is  
20    traveling. In one embodiment, according to the teachings of the present invention, the method adjusts the starting point for the new route calculation forward along the current thoroughfare on which the device is traveling a distance equal to the distance calculated in block 720. In one embodiment, the method adjusts the starting point for the new route calculation forward along to the end of the current  
25    thoroughfare on which the device is traveling.

In block 740 the method includes determining whether a straightest path along the current thoroughfare on which the device is traveling is ascertainable in order to adjust the location of the starting point forward of the device. As one of

ordinary skill in the art will understand upon reading this disclosure, the current thoroughfare on which the device is traveling can be approaching a node or intersection of streets such that there are a number of adjacencies approaching in the direction of travel. If a straightest path along the current thoroughfare on which the device is traveling is ascertainable in order to adjust the location of the starting point forward of the device such that the device will be on the route at a time when the new route calculation is completed, then the method proceeds to block 750 and calculates a new route using a starting point location which will be at or forward of the device at a time when the new route calculation completes.

However, in some instances where the device is approaching a node or intersection of streets, such that there are a number of adjacencies approaching in the direction of travel, a straightest path along the current thoroughfare on which the device is traveling is not immediately ascertainable. Therefore, simply adjusting the starting point for the new route calculation forward, even to the end of the current thoroughfare, will not suffice or does not provide an adequate distance, based on the travel speed of navigation device and the determined new route calculation time, such that the location of the starting point will be at or forward of the device at the time the new route calculation completes.

When the straightest path is not immediately ascertainable, the method proceeds to block 760 where the method evaluates a set of adjacency criteria to determine a straightest path and locate the starting point for the new route calculation somewhere along a chosen adjacency such that the starting point for the new route calculation will be at or forward of the device at a time when the new route calculation completes. According to the teachings of the present invention, the set of adjacency criteria includes, but is not limited to, the degree of turn angles between the thoroughfare on which the device is located and adjacent thoroughfares connected thereto by a node, thoroughfare names, thoroughfare classifications, speed classification of the thoroughfares, and other criteria of the like.

As stated, as used herein, the term adjacency information, or adjacencies, is intended to include any thoroughfare which intersects the current thoroughfare on which the device is traveling. Every place two roads intersect is termed a node. Thus, every node on a given thoroughfare connects that thoroughfare to an  
5 adjacency, or adjacent thoroughfare. Once the straightest path along the current thoroughfare on which the device is traveling is ascertainable in order to adjust the location of the starting point forward of the device, such that the device will be on the route at a time when the new route calculation is completed, then the method proceeds to block 750 where the method calculates the new route.

10 As shown in Figure 7, once a new route has been calculated in block 750, the method proceeds to block 770. In block 770 the method determines whether the device location is on the calculated route. If so, the method proceeds to block 780 and begins navigating the new route, including navigating the device to the starting point for the new route. In one embodiment, the method navigates the new route  
15 using both visual and audio cues.

Alternatively, according to the teachings of the present invention, if the device location is not on the calculated route then the method proceeds to block 790 and retrieves the current position of the navigation device. Next, in block 795 the method retrieves a travel velocity for the device and additionally retrieves an actual  
20 calculation time which was required to perform the previous new route calculation.

According to the teachings of the present invention, the method then returns from block 795 to block 720 and repeats the sequence described above until a new route calculation has been completed with a starting point for the new route such that the device is on the new route at the time the new route calculation completes  
25 and eventually proceeds to block 780 to start navigating the route.

In some embodiments, the methods provided above are implemented as a computer data signal embodied in a carrier wave or propagated signal, that represents a sequence of instructions which, when executed by a processor, such as

processor 410 in Figures 4A and 4B or processor 504 in Figure 5, cause the processor to perform the respective method. In other embodiments, methods provided above are implemented as a set of instructions contained on a computer-accessible medium, such as memory 430 in Figures 4A and 4B or mass storage device 512 in Figure 5, capable of directing a processor, such as processor 410 in Figures 4A and 4B or processor 504 in Figure 5, to perform the respective method. In varying embodiments, the medium is a magnetic medium, an electronic medium, or an optical medium.

As one of ordinary skill in the art will understand upon reading this disclosure, the electronic components of device 400 shown in Figures 4A and 4B and components of the system 500 shown in Figure 5 can be embodied as computer hardware circuitry or as a computer-readable program, or a combination of both. In another embodiment, system 500 is implemented in an application service provider (ASP) system.

The system of the present invention includes software operative on a processor to perform methods according to the teachings of the present invention. One of ordinary skill in the art will understand, upon reading and comprehending this disclosure, the manner in which a software program can be launched from a computer readable medium in a computer based system to execute the functions defined in the software program. One of ordinary skill in the art will further understand the various programming languages which may be employed to create a software program designed to implement and perform the methods of the present invention. The programs can be structured in an object-orientation using an object-oriented language such as Java, Smalltalk or C++, and the programs can be structured in a procedural-orientation using a procedural language such as COBOL or C. The software components communicate in any of a number of means that are well-known to those skilled in the art, such as application program interfaces (A.P.I.) or interprocess communication techniques such as remote procedure call



(R.P.C.), common object request broker architecture (CORBA), Component Object Model (COM), Distributed Component Object Model (DCOM), Distributed System Object Model (DSOM) and Remote Method Invocation (RMI). However, as will be appreciated by one of ordinary skill in the art upon reading this disclosure, the teachings of the present invention are not limited to a particular programming language or environment.

### CONCLUSION

The above systems, devices and methods have been described, by way of example and not by way of limitation, with respect to improving accuracy, processor speed and ease of user interaction with a navigation device. That is, the systems, devices and methods provide for a navigational route planning device which is more efficient and accurate than current low cost systems, without requiring the more expensive system resources. The systems, devices and methods of the present invention offer an improved navigational route planning device which provide more understandable, accurate and timely route calculation capabilities.

Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that any arrangement which is calculated to achieve the same purpose may be substituted for the specific embodiment shown. This application is intended to cover any adaptations or variations of the present invention. It is to be understood that the above description is intended to be illustrative, and not restrictive. Combinations of the above embodiments, and other embodiments will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention includes any other applications in which the above systems, devices and methods are used. The scope of the invention should be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled.